

NEW FIR LASER LINES FROM CD₃OH

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Abstract

Fourteen new optically pumped far-infrared (FIR) laser lines in the range 46.8 μm to 172.6 μm were discovered in optically pumped CD₃OH. The pump sources include both the CO₂ laser and the N₂O laser. Two theoretically predicted laser lines were observed in this study.

Far-Infrared, Methanol, CD₃OH, Optically-Pumped Laser, Laser

Introduction

The purpose of this work is to reinvestigate CD₃OH as a lasing molecules pumped by either a CO₂ laser or an N₂O laser. CD₃OH is the second most prolific methanol isotopomer (CH₃OH is first) for producing optically pumped far-infrared (FIR) laser lines. In fact, more than 400 laser lines have been identified using this molecule in the range from 22 μm to 3030 μm [1,2,3]. This isotopic species is the richest in both short (<50 μm) and long (>1000 μm) wavelength lines.

Experimental Apparatus

Two different FIR laser cavities were used: a waveguide cavity pumped by an N₂O laser and a Fabry-Perot cavity pumped by a CO₂ laser. The CO₂ laser had a 75 MHz free spectral range whose characteristics follows those described in ref. [4]. The N₂O laser design follows that described in the ref. [5].

The waveguide FIR cavity is 2 m long and is formed by a metal-dielectric rectangular waveguide formed by a pair of 64 mm wide metal plates separated by 6 mm tall glass sides [6]. The laser was longitudinally pumped through a 1 mm hole centered in a flat copper end mirror. The FIR polarization is always parallel to the metal surface of the waveguide. The

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Fabry-Perot cavity uses a nearly confocal geometry 2 m long formed by Pyrex tube with a 36 mm diameter [7]. The laser cavity consists of two concave mirrors with 1.9 m radii of curvature. The pump radiation enters the cavity through a 2.5 mm diameter hole in the fixed mirror 16.5 mm above the laser axis at an angle aimed to the center of the opposite moveable mirror yielding a *V*-type pumping. In both cavities, one end mirror was coupled to a micrometer for cavity tuning and the FIR output power was coupled out by a 45°, 6.35 mm diameter mirror in the Fabry-Perot cavity or 5.5 mm diameter mirror in the waveguide, both are radially adjustable to vary the coupling and they reflect the beam to a pyroelectric detector. In addition, a microphone was placed inside each cavity in order to record the optoacoustic signal that occurs when there is an absorption of the pump radiation by the active medium.

Results and Comments

Fourteen new FIR laser lines were discovered from the eleven strongest absorptions detected. The wavelength was measured using the cavity itself as a scanning Fabry-Perot interferometer as the movable mirror was tuned through a calibrated range containing at least 20 half-wavelengths. The wavelength obtained in this way had an uncertainty of about $\pm 0.05 \mu\text{m}$. The relative polarization of the FIR laser line to that of the pump line was measured with a multi-Brewster-angle pile-of-plates polarizer and is denoted by \perp for perpendicular and by $//$ for parallel polarization. Table I and Table II summarize the characteristics of the new FIR laser lines pumped by the CO_2 laser and the N_2O laser.

Table I: New FIR laser lines from CD₃OH pumped by the CO₂ laser.

CO ₂ Pump line	Wavelength μm	FIR laser line		
		Rel. Pol.	Pressure Pa(mTorr)	Rel. Int.
10 HR30	81.6	⊥	21 (160)	6.7
	46.8	//	13 (100)	3.3
10 HR30'	142.2	//	16 (120)	8.3
10 R56	54.4	⊥	21 (160)	1.0
10 R38	51.1	⊥	32 (240)	2.5
	53.2	//	28 (210)	4.2
10 R16	86.7	//	13 (100)	10
10 P18	52.0	⊥	15 (110)	1
	60.7	⊥	23(170)	2
10 P24	47.2	⊥	17 (130)	.17
10 P32	105.2	//	11 (80)	.67
9 P48	92.7	//	15 (110)	.17
*9P36	118.8	⊥		100

CH₃OH used as a Intensity reference

Table II: New FIR laser lines from CD₃OH pumped by the N₂O laser.

N ₂ O Pump line	Wavelength μm	FIR laser line	
		Pressure Pa(mTorr)	Rel. Int.
10R31	142.0	21 (160)	2
10R16	172.6	27 (200)	1.7

The new FIR laser lines pumped by the 10 P(18) CO₂ laser line were the most important from a spectroscopic point of view. In fact, they were predicted recently [8] to be at 167.4914 cm⁻¹ and 192.4581 cm⁻¹ and both with relative polarization perpendicular. In this work, they were identified at 164.7 cm⁻¹ and 192.3 cm⁻¹ and the relative polarization was perpendicular in agreement with the proposed assignment.

Conclusion

The CD₃OH isotopomer was pumped by a CO₂ laser and a N₂O laser and produced fourteen new FIR laser lines in the range from 46.8 μm to 172.6 μm; most having wavelengths below 100 μm. The new FIR laser lines pumped by 10 P(18) CO₂ laser had been theoretically predicted previously.

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